Logging Equipment, Methods, and Cost for Near Complete Harvesting of Lodgepole Pine in Wyoming

Techniques

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Abstract

Lodgepole pine (Pinus contorta Dougl.) in Wyoming was logged to near complete standards using a feller-buncher, grapple and choker rubber-tired skidders, and a portable chipper. Cost of removing the commercial timber was comparable to costs incurred in conventional harvesting. Cost of removing the logging residue and chipping it on the site shows promise for future utilization. A more efficient logging system is simulated and proposed for reducing the costs of near complete harvesting in the future.

Introduction

A cooperative study of the economic feasibility and environmental impacts of near complete harvesting of lodgepole pine (*Pinus contorta* Dougl.) in the Union Pass area, Teton National Forest, Wyoming, was begun in the summer of 1971. The cooperators are the USDA Forest Service, Intermountain Forest and Range Experiment Station, Intermountain Region; and Champion International. The logging was completed in the fall of 1971. A report on the initial findings of this study was published in April 1972 as an Intermountain Forest and Range Experiment Station Research Note (USDA Forest Service Research Note INT-160, "Utilization of Lodgepole Pine Logging Residues in Wyoming Increases Fiber Yield"). It reported that fiber yields were increased by 35 percent using near complete harvesting standards.

This report discusses the equipment, methods, and costs of logging in this study area. The effects of these logging methods on regeneration, nutrient cycling, hydrology, wildlife, esthetics, and overall costs and benefits will be reported as data become available and are evaluated.

Description of Logging Units

Two blocks, each about 40 acres, were laid out in similar stands of lodgepole pine. One half of each block, designated a cutting unit, was harvested to conventional clearcutting standards, the other half was harvested to "near complete" standards. The cutting units, numbered 1 through 4, totaled approximately 80 acres (fig. 1). Conventional harvesting called for the removal (as logs) of all merchantable trees to a minimum top diameter of 6 inches. The near complete standards included, in addition to removal of logs, the chipping of the tops and limbs of all merchantable trees, all remaining live and standing sound dead trees 3 inches d.b.h. and larger, and all sound down material over 6 inches in diameter at the large end and longer than 6 feet. As previously reported, removal of this material increased fiber yield by 35 percent and left the site ready for planting without additional cleanup, site preparation, or burning to reduce fire hazards (fig. 2).

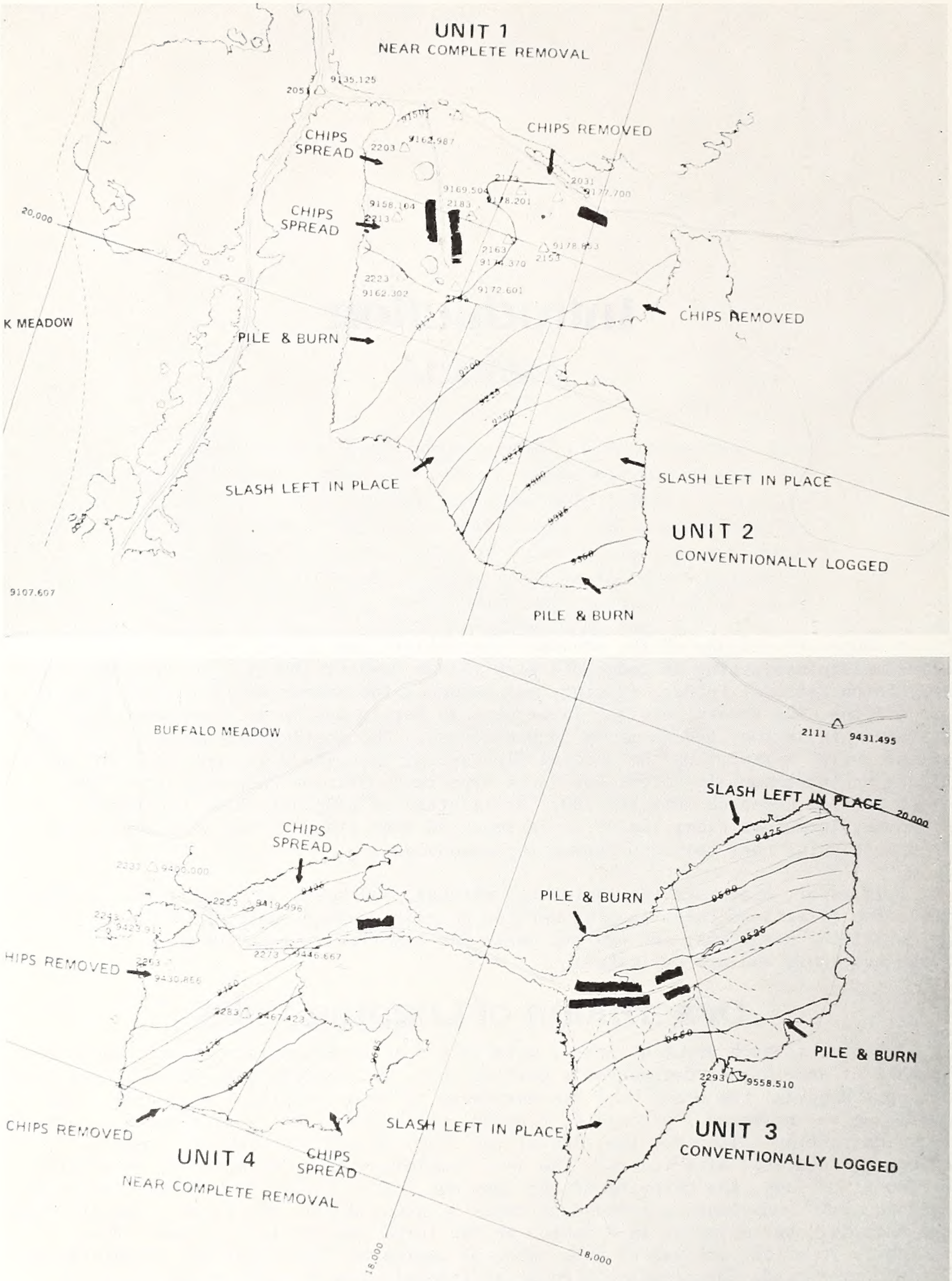

Figure 1.--Layouts of conventional and near complete harvest units.

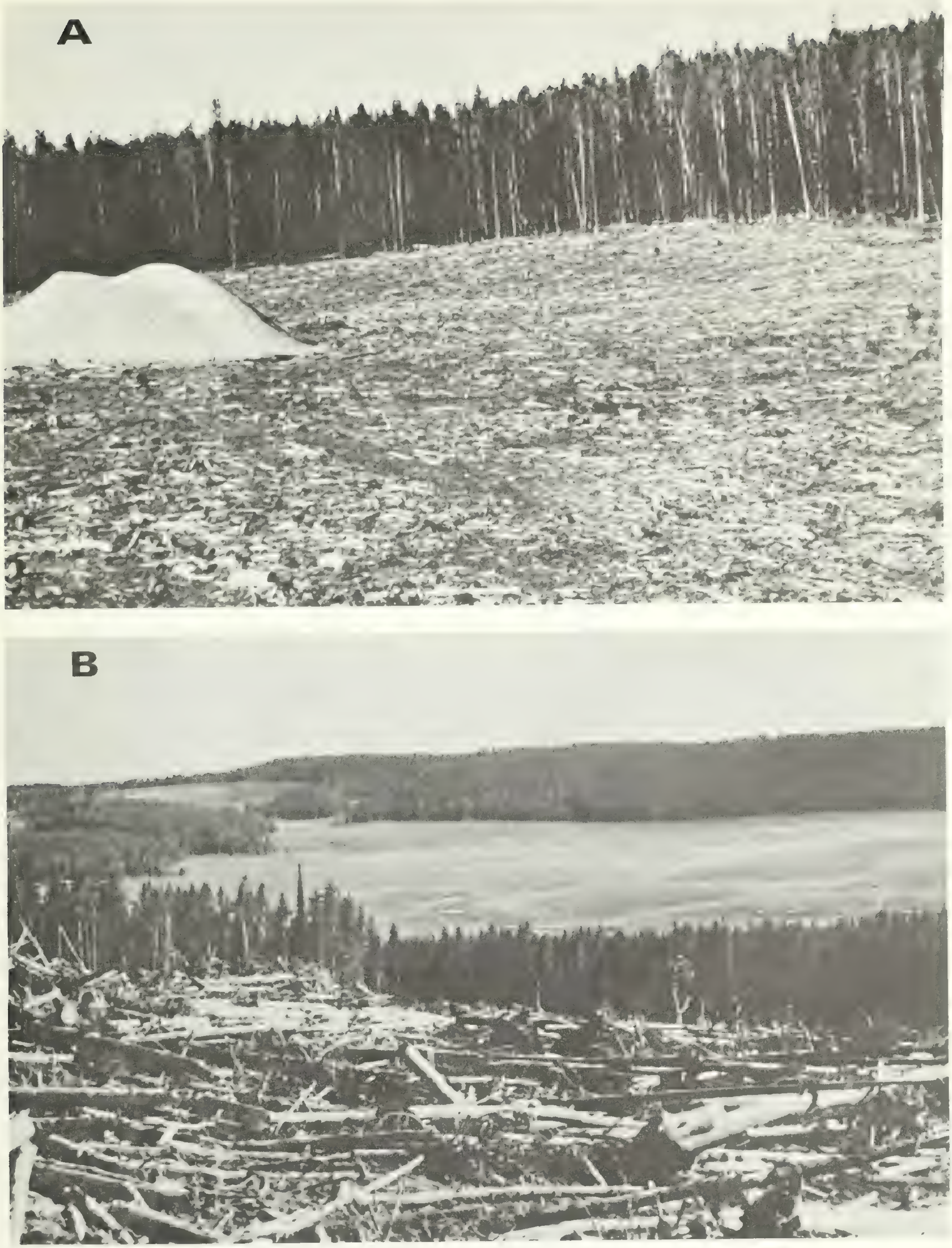

Figure 2.--A. Harvesting unit 1 (near complete); B, harvesting unit 2 (conventional).

Logging Methods and Equipment

Since there was no past experience with near complete harvesting, equipment on the market was studied and a logging system was designed that would have good prospects for economic success. The potential market for residues would be for pulp or reconstituted wood products; therefore, logging debris had to be chipped. All residue, including bark, limbs, and needles, was chipped in a portable chipper at the landing (fig. 3). Trees were felled with a feller-buncher (fig. 4) and were skidded with both rubber-tired and crawler skidders (fig. 5). Logs were bucked and limbed with chainsaws at the landing, loaded on trucks with a heelboom loader, and were hauled to mill by contract haulers.

All of the merchantable logs were transported 40 miles to the U.S. Plywood mill at Dubois, Wyoming. Part of the chips produced at the site were used for experimental pulping and particle board manufacture by Champion International and the U.S. Forest Products Laboratory. The remainder will be used for experimental spreading over test plots at the site, or disposed of off site.

Figure 3.--Chipharvestor in operation at landing.

Figure 4.--Drott Feller-Buncher felling tree.

Figure 5.--Timberjack Grapple Skidder skidding logs.

The equipment used for the near complete harvesting treatment consisted of the following:

Feller-Buncher:

1 - Model 40 LC Drott Feller-Buncher

Chipper:

1 - Model SL-22 Morbark Chipharvestor

Skidders:

1 - Timberjack Grapple Skidder, Model 230D
1 - Garrett Treefarmer, Model 21-A (with ESCO Grapple, Model 112)
1 - Garrett Treefarmer, Model 21-A
2 - Clark Rangers, Model 666

Combination Equipment (skidding, dozing, slash piling):

2 - Caterpillar tractors, Model D-6, 9U Series
3 - International Tractors, Model TD15B
1 - International Tractor, Model TD20C

Loader:

1 - Oshkosh Truck, 1951 with Beloit Model L166 Heelboom Loader

The equipment listed above, with the exception of the feller-buncher, chipper, and grapple skidder, was also used to log the conventional harvest units.

Auxiliary Equipment:

Ford Truck (Mechanic), Model N600, 1967
Ford Truck (Transport), Model N600, 1968
Ford Truck (Transport), Model F350, 1969
Ford Truck (Woods Boss), Model F250FWD, 1968
Ford Truck (Service), Model N600, 1969

Specifications for the special equipment (feller-buncher, chipper, and grapple skidder) are included in the Appendix.

PART 1:
Logging Production and Costs

Logging production was recorded daily for each piece of equipment (Gross Data). Time was recorded for operational, delay, and down periods. Merchantable volumes were weight-scaled, and nonmerchantable chip volumes were measured in piles at the landing. A separate piece count was recorded for merchantable and nonmerchantable material handled by the feller-buncher and the skidders.

Production data were converted to cost by using industry's average equipment costs and wage rates for the area. The costs represent only the direct cost of logging and supervision at the field level. Overhead items such as payroll cost, general administration, etc., are not included.

Table 1 summarizes costs and shows the cost of each operation for each unit. Units 1 and 4 were the near complete harvesting units, and 2 and 3 were conventionally harvested units. Harvest statistics for each unit are shown in table 2.

For this study, the chips were piled at the site for later experimental use. In a commercial operation, they would be blown into vans and transported to the mill. The cost of transporting chips is estimated from going rates and is shown in table 1.

The cost of harvesting and delivering merchantable logs to the mill are similar for both methods and are primarily influenced by piece size for the felling, bucking, and skidding operations.

Table 1.--*Operational cost summary ($/Mfbm or BDU)*

Operation	Harvest units					
	1 (near complete)		4 (near complete)		2 (conventional)	3 (conventional)
	Mfbm[1]	*BDU*[2]	*Mfbm*	*BDU*	*Mfbm*	*Mfbm*
Fell & Buck (Merchantable Volume)	$ 9.40	--	$ 8.90	--	$ 7.86	$ 7.20
Felling (Feller-Buncher)	[3](3.50)	$ 1.96	[3](2.96)	$ 0.99	--	--
Skidding	5.05	5.52	4.11	5.23	7.75	6.83
Landing[4] Equipment Cost	--	0.80	--	1.29	--	--
Chasing	1.92	--	2.50	--	1.29	0.90
Chipping	--	3.94	--	3.86	--	--
Loading	0.96	--	0.66	--	0.85	0.88
Service	0.80	0.24	0.76	0.25	0.48	0.55
Hauling[5]	12.90	6.48	12.90	6.48	12.90	12.90
Decking and Road Cost	3.81	1.32	2.44	0.88	4.08	1.85
Total						
Merchantable	$34.82		$32.27		$35.21	$31.11
Chips		$20.26		$18.89		

[1] Mfbm = thousand foot board measure.
[2] BDU = 2,400 lb bone dry unit.
[3] Included in total F&B above.
[4] Used primarily to forward material to chipper.
[5] Contracted; hauling for 40 miles.

Table 2.--*Harvest unit production*

Item	Harvest unit			
	1	4	2	3
Size (acre)	16.8	17.2	21.7	22.5
Net merchantable volume (Mfbm/acre)	14.7	15.2	25.1	21.4
Chip weight (BDU/acre)	50.0	45.4	--	--
Average piece size (Logs/Mfbm)	13.7	7.9	15.8	13.4

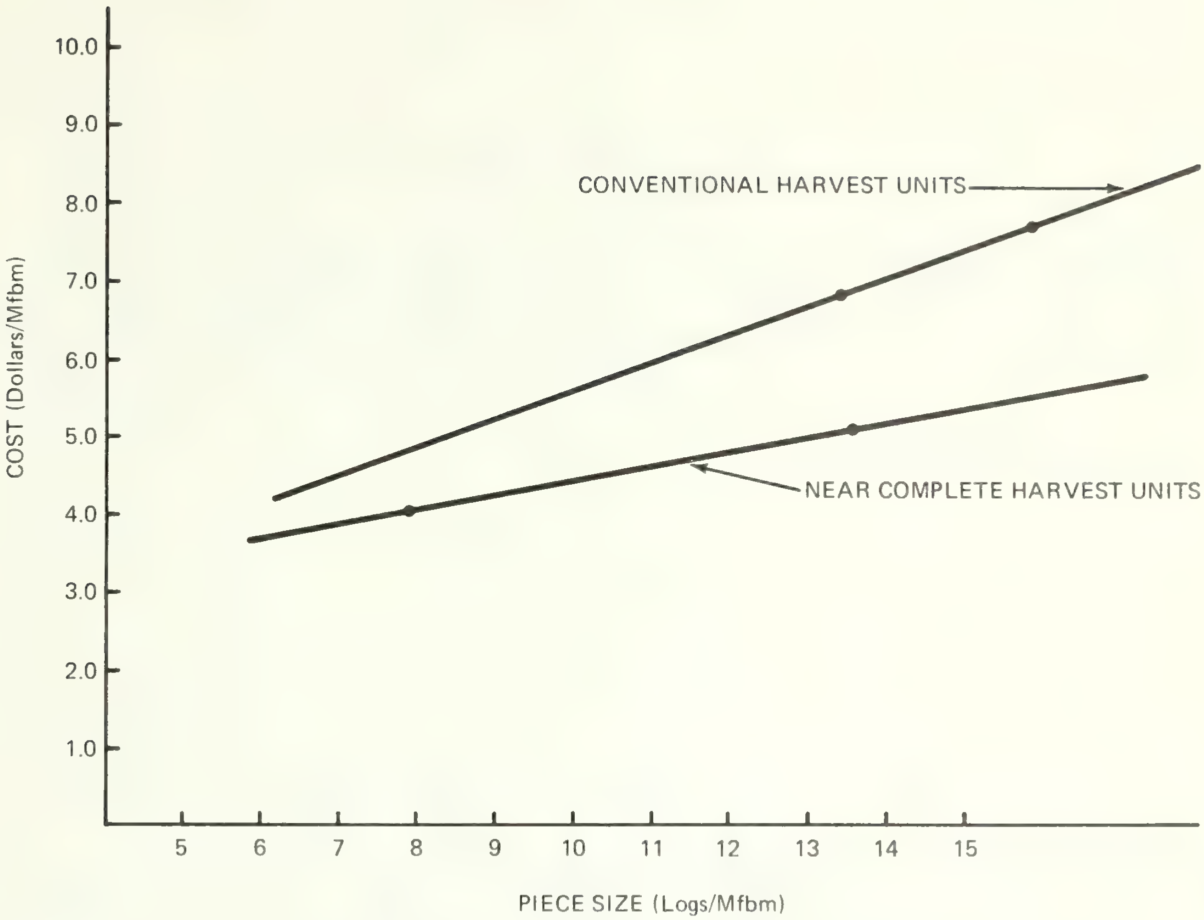

Figure 6.--Skidding cost versus piece size.

The slope of the curves in figure 6 indicates that in near complete harvesting skidding costs are lower and are less sensitive to piece size than in conventional harvesting. This is mainly because it is more efficient to skid small trees whole than to skid them in pieces. Another possible explanation for reduced cost is that it was not considered practical to remove defects from full trees skidded to the landing. Instead, the entire tree was chipped, which reduced the cost of handling small merchantable logs. (This is also the primary reason for lower merchantable volumes harvested in Units 1 and 4.) Also, in other skidding studies, prebunching of merchantable material has been shown to reduce skidding costs.

The cost of handling and piling the nonmerchantable material (top and limbs) in Units 1 and 4 could be charged against the merchantable volume rather than to the production of BDU's of chips, as was done in this study. Best allocation of these costs can be determined in future sales when and if this level of utilization becomes commercially profitable.

Experience gained from this study and analysis of production capabilities of equipment used for the near complete harvesting units indicates that cost savings could be realized by more careful planning. These possibilities are investigated in Part II.

PART 11:

Recommended Logging Operation for Near Complete Harvesting

As suggested in the conclusion of Part I, costs could probably be lowered significantly by using the most productive equipment for each operation. Table 1 in Part I reports the cost of logging as experienced during the actual operation. In Part II, selecting the most productive units and combining those into a well-scheduled operation gives at least an order of magnitude estimate of possible improvement in cost.

Production Capabilities, Planning, and Scheduling

To simplify the process of system design and scheduling, all fiber units of measurement were converted to bone dry tons (BDT). Table 3 shows the tonnage harvested in both units.

Table 3.--*Bone dry tonnage (2,000 lb) by unit*

Unit	Merchantable	Nonmerchantable	Total
1	725	1,020	1,745
4	775	936	1,711
Total	1,500	1,956	3,456
Percent	43.5	56.5	100

Table 4.--*Harvesting system costs based on production capabilities*

Equipment	Operation cost including wages	Production capacity[1]	Cost: Balanced operation (System I)[2]	Cost: Maximum capacity (System II)
	$/hr	*BDT/hr*	*$/BDT/hr*	*$/BDT/hr*
Drott Feller-Buncher	15.25	25.45	0.600	0.600
Timberjack Grapple Skidder	11.26	14.86	.905	.758
Morbark Metro Chipharvestor	29.50	34.00	1.359	.867
Heelboom Loader	13.25	23.70	.559	.559
Transport				
Bunks	24.20	5.2	5.410	5.410
Vans	24.26	3.9		
Total			$8.833	$8.194

[1]Using productive hours only; i.e., deducting idle time.
[2]See table 5.

Table 4 gives hourly operating costs and production capabilities of the equipment used in a proposed logging operation in dollars and bone dry tons of fiber, respectively. In the last two columns, production in dollars per bone dry ton per hour is given for equipment (operating at the capacity experienced during the study) for a balanced hot logging operation (System I) and a scheduled operation that provides for each equipment type operating at full capacity (System II). Table 5 shows what is meant by a balanced operation--if all of the equipment is moved to the job about the same time, then the entire harvesting operation would produce at the rate of the least productive element. In this case, it would be the feller-buncher; i.e., 25.45 BDT/hr. Table 5 defines the number of units of each class of equipment needed for a balanced logging operation (column 3). In a hot logging operation, all elements or subsystems operate simultaneously. In column 5, the percentage of utilization of each class of equipment is shown. Columns 6 and 7 are used for scheduling the equipment on the job as shown in figure 7.

From Table 4, the costs are $8.83/BDT and $8.19/BDT for Systems I and II, respectively. If these two systems were to operate at 80 percent efficiency, which is a reasonable goal, then the costs are $11.02 and $10.22. These figures are exclusive of landing, and supervision, crew transportation, and service, which were computed to be as follows:

Landing	$1.67/BDT
Supervision, Transportation, Service	.42/BDT
	$2.09/BDT

These costs must be added to the other costs $; i.e., $11.02 + $2.09 = $13.11, and $10.22 + $2.09 = $12.31, respectively.

Table 5.--*Planning harvesting systems using production capabilities*

Equipment (1)	Production capacity (2)	No. units (3)	Production (4)	Percent utili- zation (5)	Time to harvest both units[1] (6)	Difference from minimum production unit (7)
	BDT/hr		*BDT/hr*	*Percent*	*Hr*	*Hr*
Drott Feller-Buncher	25.45	1	25.45	100.0	135.5	0
Timberjack Grapple Skidder	14.86	2	29.72	85.6	116.0	-19.5
Morbark Metro Chipharvestor	34.00	1	34.00	42.0	57.5	-78.0
Heelboom Loader	23.70	1	23.70	47.0	63.5	-72.0
Transport						
Bunks	5.2	4	20.80	100.0	72.0	-63.5
Vans	3.9	8	31.20	100.0	62.5	-73.0

[1]3,456 BDT from table 3 (1,956 BDT, nonmerchantable - 1,500 BDT, merchantable).

Table 6 summarizes and compares costs for the actual operation in Part I and the two simulated harvesting operations in Part II.

How unit costs compare for the actual operation and the simulated operation, working at maximum capacity (System II), is shown below:

Operation	*Merchantable* *$/Mfbm*	*Nonmerchantable* *$/BDU*
Actual	33.50	19.81
Simulated (System II)	28.70	16.60

These figures are weighted averages for the near complete harvesting units (1, 4) for both harvesting systems; i.e., the actual and the simulated operations.

Table 6.--*Cost summary for harvesting systems*

Harvesting system	Cost/BDT	Difference from actual	Difference
	- - - - *Dollars*	- - - -	*(Percent)*
Actual	[1]$14.58		
System I	$13.11	$1.47	9.9
System II	$12.31	$2.27	15.5

[1]Weighted average of Units 1 and 4 computed from Part I by converting from BDU to BDT.

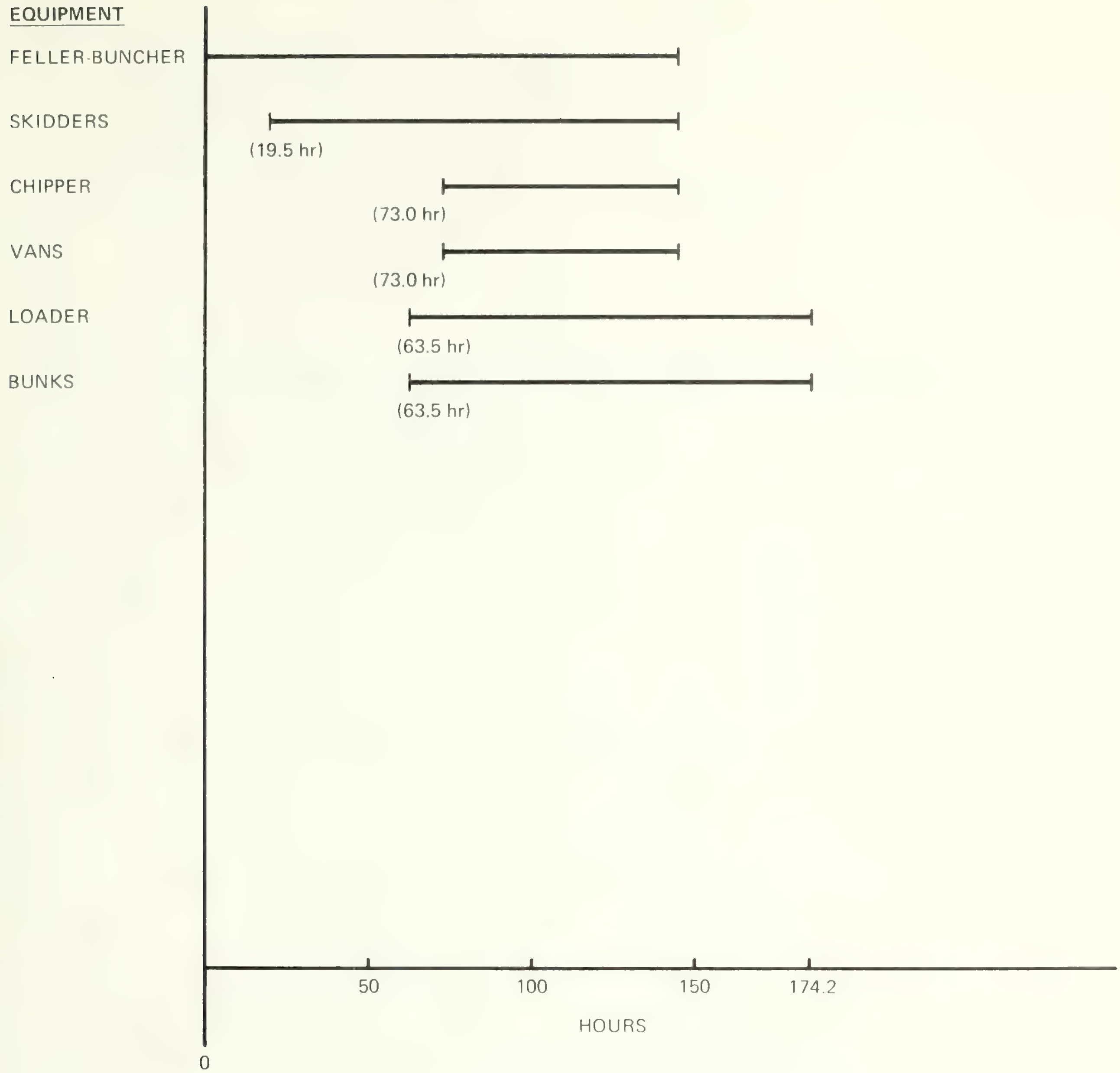

Figure 7.--Equipment scheduling for operation at maximum capacity.

Summary and Conclusions

The costs of harvesting merchantable material using conventional harvesting and near complete harvesting were almost the same: $33.27/Mfbm and $33.50/Mfbm, respectively. The cost of harvesting the nonmerchantable material indicates that a net profit *per acre* in a near complete harvest may be possible if markets develop for the residue.

It has been shown in Part II that a significant cost savings is possible in a carefully scheduled operation using the most productive equipment.

Further savings would be possible after the crews have had more experience with this method of logging.

In conclusion, more complete utilization of the fiber resource may be possible in the future by using near complete harvesting methods and carefully planned harvesting operations.

Appendix

General Specifications

Feller-Buncher - Drott Model 40 LC

Width	11'
Height	11' 8"
Weight	44,960 lb
Prime power	GMC Diesel 4-71
Maximum reach (from C.G.*)	25'
Maximum tree size (softwoods)	24"
Continuous rotating platform	(360°)

Chipharvestor - Morbark Model SL-22

Width	8' 10"
Height	13' 4"
Weight (approx.)	52,000 lb
Prime power	GMC Diesel 8V-71
Feed rate	120 lin. ft/min
Maximum tree size	22"

Grapple Skidder - Timberjack Model 230D

Width	8' 1"
Height	7' 11"
Weight	12,740 lb
Power	GMC Diesel 3-53
Tires (standard)	18.4 X 34
Speed range	2.22 - 17.64 mi/h
Grapple opening	8' 6.5"
Maximum horizontal reach	8' 5"

* C.G. = Center of gravity

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